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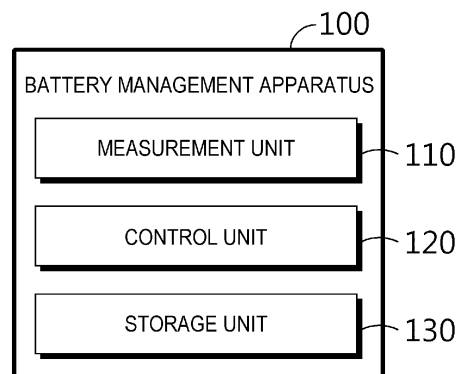
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(54) **BATTERY MANAGEMENT DEVICE AND METHOD, AND BATTERY PACK COMPRISING SAME**

(57) A battery management apparatus includes: a voltage meter that measures voltages of a plurality of batteries connected in series to each other; and a controller that estimates State of Charges (SOCs) of the plurality of batteries based on the measured voltages,

and control charge and discharge of the plurality of batteries to make the estimated SOC of the plurality of batteries fall within a plurality of usable SOC bands preset to correspond to the plurality of batteries.

FIG. 1



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Description

TECHNICAL FIELD

[0001] This application is based on and claims priority from Korean Patent Application No. 10-2023-0018298, filed on February 10, 2023, with the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

[0002] The present disclosure relates to a battery management apparatus, a battery management method, and a battery pack including the battery management apparatus.

BACKGROUND

[0003] Recently, the demand for portable electronics including laptops, video cameras, and mobile phones has increased dramatically, and the development of electric vehicles, energy storage batteries, robots, and satellites has accelerated. Under the circumstances, research is being actively conducted on high-performance rechargeable batteries.

[0004] Presently, commercially available batteries include nickel-cadmium batteries, nickel-hydrogen batteries, nickel-zinc batteries, and lithium batteries. Of these batteries, lithium batteries are emerging as the most popular, as they do not suffer from the memory effect and therefore are freely rechargeable, have low self-discharge rates, and have high energy density, as compared to nickel-based batteries.

[0005] In graphite-based batteries, the staging phenomenon may occur as lithium is intercalated into graphite layers. In the staging phenomenon related to the lithium intercalation reaction, a transition from a high stage to a low stage is observed as the lithium insertion concentration increases. In contrast, in a lithium deintercalation reaction (discharge reaction), the transition takes place in reverse.

[0006] An SOC (state of charge) band in which the graphite staging phenomenon occurs may be referred to as a staging band. Degradation of batteries may be accelerated when charged and discharged in the staging band, as compared to when charged and discharged outside the staging band. For example, batteries that have been continuously charged and discharged in the staging band may degrade more quickly than batteries that have not been charged and discharged in the staging band.

[0007] Therefore, the development of technologies for improving the life expectancy of batteries by limiting the charge and discharge in the band that may affect the degradation of batteries is required.

SUMMARY

[0008] The present disclosure is designed to solve the above problems, and the present disclosure provides a

battery management apparatus and a battery management method for controlling the charge and discharge of batteries to extend the life of the batteries, and a battery pack including the battery management apparatus.

[0009] Advantages of the present disclosure may be understood from the descriptions herein below, and may more clearly be comprehended from embodiments of the present disclosure. Further, it will be apparent that the objects and advantages of the present disclosure may be implemented by the means defined in the claims and combinations thereof.

[0010] According to an aspect of the present disclosure, a battery management apparatus may include: a voltage meter that measures voltages of a plurality of batteries connected in series to each other; and a controller that estimates State of Charges (SOCs) of the plurality of batteries based on the measured voltages, and control charge and discharge of the plurality of batteries to make the estimated SOC of the plurality of batteries fall within a plurality of usable SOC bands preset to correspond to the plurality of batteries.

[0011] The plurality of usable SOC bands may be divided based on preset non-usable SOC bands, and set to not overlap with each other.

[0012] The controller may control an operation state of a bypass switch disposed in a bypass path connected in parallel to each of the plurality of batteries.

[0013] During the charge of the plurality of batteries, the controller may select a target battery with an SOC reaching an upper limit value of a usable SOC band corresponding to the target battery, and control the operation state of the bypass switch connected in parallel to the target battery to an ON state.

[0014] During the discharge of the plurality of batteries, the controller may select a target battery with an SOC reaching a lower limit value of a usable SOC band corresponding to the target battery, and control the operation state of the bypass switch connected in parallel to the target battery to an ON state, thereby stopping the discharge of the target battery.

[0015] When the plurality of batteries are requested to be discharged despite that the SOC of the plurality of batteries have reached lower limit values of the usable SOC bands corresponding to the plurality of batteries, the controller may set priorities among the plurality of usable SOC bands in a decreasing order of band values of the plurality of usable SOC bands, and discharge the plurality of batteries from batteries corresponding to a usable SOC band with a highest priority to batteries corresponding to a usable SOC band with a lowest priority.

[0016] When the SOC of further discharged batteries reach a lower limit value of a usable SOC band with a subsequent priority, the controller may further discharge batteries corresponding to the usable SOC band with the subsequent priority.

[0017] The controller may set intervals of the plurality of usable SOC bands to be equal to each other.

[0018] The controller may set a different number of

batteries to correspond to each of the plurality of usable SOC bands.

[0019] The controller may set the different number of batteries such that the larger a band value of a usable SOC band, the greater the number of batteries corresponding to the SOC band.

[0020] According to another aspect of the present disclosure, a battery pack may include the battery management apparatus described above.

[0021] According to yet another aspect of the present disclosure, a battery management method may include: measuring voltages of a plurality of batteries connected in series to each other; estimating SOC of the plurality of batteries based on the voltages; and controlling charge and discharge of the plurality of batteries to make the SOC of the plurality of batteries fall within a plurality of usable SOC bands preset to correspond to the plurality of batteries.

[0022] According to an aspect of the present disclosure, a battery management apparatus may control charge and discharge of a plurality of batteries such that the SOC (State of Charge) of each of the plurality of batteries does not fall within a non-usable SOC band.

[0023] According to an aspect of the present disclosure, there are advantages in that the life expectancy of the plurality of batteries is extended, and the unbalance in degradation of the plurality of batteries is prevented.

[0024] The effects of the present disclosure are not limited to the effects mentioned above, and other effects not mentioned will be clearly understood by those skilled in the art from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Since the drawings attached herewith serve to facilitate the understanding of the technical idea of the present disclosure in conjunction with the detailed description of the invention herein below, the present disclosure should not be construed as being limited to the matters illustrated in the drawings.

FIG. 1 is a view schematically illustrating a battery management apparatus according to an embodiment of the present disclosure.

FIG. 2 is a view schematically illustrating an example of a configuration of a battery pack according to another embodiment of the present disclosure.

FIGS. 3 to 7 are diagrams illustrating Example 1 according to the present disclosure.

FIGS. 8 to 12 are diagrams illustrating Example 2 according to the present disclosure.

FIG. 13 is a flow diagram schematically illustrating a battery management method according to yet another embodiment of the present disclosure.

DETAILED DESCRIPTION

[0026] Words and terms used in the detailed descrip-

tion and the claims herein should not be interpreted to be limited to their usual or dictionary meanings, but should be interpreted to have meanings and concepts that correspond to the technical idea of the present disclosure in compliance with the principle that inventors may appropriately define terms and concepts for the purpose of best describing the present disclosure.

[0027] Thus, it can be appreciated that the embodiments described herein and the configurations illustrated in the drawings are merely example embodiments of the present disclosure, which do not exhaustively represent the technical idea of the present disclosure, and various equivalents and modifications may be made to substitute the present disclosure at the time of filing the present disclosure.

[0028] Further, when describing the present disclosure, detailed description of related well-known configurations or functions may be omitted if determined to obscure the gist of the present disclosure.

[0029] Terms with ordinal numbers such as first, second and so on may be used to discriminate various components from one another, and should not be interpreted as limiting the components.

[0030] Throughout the descriptions herein, when a certain part "includes" a specific component, this description does not indicate that the certain part excludes other components, but indicates that the part may further include other components, unless otherwise defined.

[0031] Further, throughout the descriptions herein, when two components are "connected" to each other, this description indicates not only that the two components are "directly connected" to each other, but also that the two components are "indirectly connected" to each other via another component.

[0032] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

[0033] FIG. 1 is a view schematically illustrating a battery management apparatus 100 according to an embodiment of the present disclosure.

[0034] Referring to FIG. 1, the battery management apparatus 100 may include a measurement unit 110 and a control unit 120.

[0035] The measurement unit 110 may be configured to measure voltages of a plurality of batteries B connected, for example, in series to each other.

[0036] Here, each battery indicates a single independent cell that is physically separable with an anode terminal and a cathode terminal included therein. For example, the battery may be a lithium ion battery or a lithium polymer battery. Further, the battery may indicate a battery module including a plurality of cells connected in series and/or parallel to each other. Hereinafter, for the convenience of description, it is assumed that the battery indicates a single independent cell.

[0037] The measurement unit 110 may be connected to the control unit 120 for a communication with the control unit 120. The measurement unit 110 may mea-

sure the voltage of each of the plurality of batteries B, and transmit information of the measured voltage to the control unit 120.

[0038] The control unit 120 may be configured to estimate the SOC (state of charge) of each of the plurality of batteries B based on the voltage received from the measurement unit 110.

[0039] For example, the control unit 120 may estimate the SOC from the voltage of each of the plurality of batteries B by using a table (e.g., a look up table (LUT)) representing an association relationship between voltages and SOC. The table may be initially set based on batteries in the BOL (beginning of life) state. The table may be updated to correspond to the degrading states of the plurality of batteries B. For example, the updated table may represent the association relationship between the voltages and the SOC of the degrading batteries.

[0040] The control unit 120 may be configured to control the charge and discharge of the plurality of batteries B such that the SOC of the plurality of batteries B fall within a plurality of usable SOC bands set in advance to correspond to the plurality of batteries B.

[0041] The usable SOC bands may be set based on preset non-usable SOC bands. Further, the usable SOC bands may be set to not overlap with each other. For example, the non-usable SOC bands may be SOC bands preset to be unusable because the degradation of batteries may be accelerated during the charge and discharge in the non-usable SOC bands. As an example, the non-usable SOC bands may include an SOC band including 90 % to 100 % SOC in which a battery is fully charged, an SOC band including 0 % to 10 % SOC in which a battery is fully discharged, and an SOC band known as the graphite staging band. These are merely examples, and the non-usable SOC bands may be further set through experiments on whether the battery degradation is accelerated.

[0042] The control unit 120 may set the plurality of usable SOC bands based on the preset non-usable SOC bands. Then, the control unit 120 may set a usable SOC band corresponding to each of the plurality of batteries B.

[0043] For example, it is assumed that four batteries B1 to B4 are provided, and a first usable SOC band U1 and a second usable SOC band U2 are set. The control unit 120 may set a first battery B1 and a second battery B2 to correspond to the first usable SOC band U1. The control unit 120 may set a third battery B3 and a fourth battery B4 to correspond to the second usable SOC band U2. For example, the control unit 120 may set arbitrary usable SOC bands corresponding to the plurality of batteries B, regardless of the current SOC or voltages of the plurality of batteries B.

[0044] The control unit 120 may be configured to control the charge and discharge of the plurality of batteries B such that the SOC of the plurality of batteries B fall within their corresponding usable SOC bands.

[0045] Specifically, the control unit 120 may control the charge and discharge of each of the plurality of batteries B such that the SOC of each of the plurality of batteries B falls within its corresponding usable SOC band.

[0046] For example, when the SOC of a certain battery reaches a lower limit value of the usable SOC band corresponding to the battery, the control unit 120 may terminate the discharge of the battery. Meanwhile, when the SOC of another battery reaches an upper limit value of the usable SOC band corresponding to the battery, the control unit 120 may terminate the charge of the battery.

[0047] That is, the battery management apparatus 100 may control the charge and discharge of the plurality of batteries B such that the SOC of the plurality of batteries B do not fall in the non-usable SOC bands. According to the present disclosure, the life expectancy of the plurality of batteries B is extended.

[0048] Meanwhile, the control unit 120 of the battery management apparatus 100 may selectively include, for example, a processor, an application-specific integrated circuit (ASIC), other chipsets, logic circuits, registers, a communication modem, and a data processor, which are well-known in the art, to execute various control logics according to the present disclosure. When control logics are implemented by software, the control unit 120 may be implemented as a set of program modules. At this time, the program modules may be stored in a memory, and executed by the control unit 120. The memory may be provided inside or outside the control unit 120, and connected to the control unit 120 as any of various well-known means.

[0049] The battery management apparatus 100 may further include a storage unit 130. The storage unit 130 may store, for example, data or programs necessary when each component of the battery management apparatus 100 performs its operation and function, and data and the like generated during the performance of the operation and function. The type of the storage unit 130 is not particularly limited as long as the storage unit 130 is a known information storing means in which recording, erasing, updating, and reading of data may be performed. Examples of the information storing means may include a RAM, a flash memory, a ROM, an EEPROM, and a register. Further, the storage unit 130 may store program codes that define processes executable by the control unit 120.

[0050] For example, the storage unit 130 may store information of the non-usable SOC bands, information of the usable SOC bands, and information of the association relationship between the plurality of usable SOC bands and the plurality of batteries.

[0051] The control unit 120 may be configured to control the operation state of a bypass switch S disposed in a bypass path connected in parallel to each of the plurality of batteries B, thereby controlling the charge and discharge of the plurality of batteries B.

[0052] Specifically, the plurality of batteries B may be connected in series to each other. Thus, the bypass

switch S may be connected in parallel to each of the plurality of batteries B, for the charge and discharge control by the control unit 120. By controlling the operation state of the bypass switch S to an ON or OFF state, the control unit 120 may control the charge and discharge of the plurality of batteries B.

[0053] FIG. 2 is a view schematically illustrating an example of a configuration of a battery pack 1 according to another embodiment of the present disclosure.

[0054] In the embodiment of FIG. 2, the plurality of batteries B may include a first battery B1, a second battery B2, a third battery B3, and a fourth battery B4. A plurality of bypass switches S may include a first bypass switch S1, a second bypass switch S2, a third bypass switch S3, and a fourth bypass switch S4. The first bypass switch S1 may be connected in parallel to the first battery B1, and the second bypass switch S2 may be connected in parallel to the second battery B2. The third bypass switch S3 may be connected in parallel to the third battery B3, and the fourth bypass switch S4 may be connected in parallel to the fourth battery B4.

[0055] In the process of charging the plurality of batteries B, the control unit 120 may be configured to select a target battery of which SOC reaches the upper limit value of the usable SOC band corresponding to the target battery, during the charge of the plurality of batteries B. The control unit 120 may be configured to control the operation state of the bypass switch S connected in parallel to the target battery to the ON state.

[0056] For example, in the embodiment of FIG. 2, it may be assumed that the SOC of the first battery B1 reaches the upper limit value of the corresponding usable SOC band, and the SOC of the second battery B2, the third battery B3, and the fourth battery B4 do not reach the upper limit values of the corresponding usable SOC bands. The control unit 120 may select the first battery B1 as a target battery. Then, the control unit 120 may control the operation state of the first bypass switch S1 to the ON state, and the operation states of the second bypass switch S2, the third bypass switch S3, and the fourth bypass switch S4 to the OFF state. In this case, the charge of the first battery B1 is terminated, and the charge of the second battery B2, third battery B3, and fourth battery B4 may continue.

[0057] Meanwhile, in the process of discharging the plurality of batteries B, the control unit 120 may be configured to select a target battery of which SOC reaches the lower limit value of the usable SOC band corresponding to the target battery, during the discharge of the plurality of batteries B. The control unit 120 may be configured to control the operation state of the bypass switch S connected in parallel to the target battery to the ON state.

[0058] For example, in the embodiment of FIG. 2, it may be assumed that the SOC of the second battery B2 and the fourth battery B4 reach the lower limit values of the corresponding usable SOC bands, and the SOC of the first battery B1 and the third battery B3 do not reach

the lower limit values of the corresponding usable SOC bands. The control unit 120 may select the second battery B2 and the fourth battery B4 as target batteries. Then, the control unit 120 may control the operation states of the second bypass switch S2 and the fourth bypass switch S4 to the ON state, and the operation states of the first bypass switch S1 and the third bypass switch S3 to the OFF state. In this case, the discharge of the second battery B2 and the fourth battery B4 may be terminated, and the discharge of the first battery B1 and the third battery B3 may continue.

[0059] FIGS. 3 to 7 are diagrams illustrating Example 1 according to the present disclosure.

[0060] Hereinafter, Example 1 will be described, assuming that the SOC range of above 90 % and 100 % or lower is set as a first non-usable SOC band N1, the SOC range of 60 % to 90 % is set as a first usable SOC band U1, the SOC range of above 40 % and below 60 % is set as a second non-usable SOC band N2, the SOC range of 10 % to 40 % is set as a second usable SOC band U2, and the SOC range of 0 % or more and below 10 % is set as a third non-usable SOC band N3. Further, it is assumed that the first battery B1 and the second battery B2 are set to correspond to the first usable SOC band U1, and the third battery B3 and the fourth battery B4 are set to correspond to the second usable SOC band U2.

[0061] In the Example of FIG. 3, the first battery B1, the second battery B2, the third battery B3, and the fourth battery B4 may be initially in the fully charged state. For example, the SOC of the first battery B1, the second battery B2, the third battery B3, and the fourth battery B4 may be 100 %.

[0062] In the Example of FIG. 4, the first battery B1, the second battery B2, the third battery B3, and the fourth battery B4 may be discharged. The SOC of the first battery B1, the second battery B2, the third battery B3, and the fourth battery B4 may reach 60 %, which is the lower limit value of the first usable SOC band U1.

[0063] Since the SOC of the first battery B1 and the second battery B2 reach the lower limit value of the first usable SOC band U1, the control unit 120 may set the first battery B1 and the second battery B2 as target batteries. Then, the control unit 120 may terminate the discharge of the first battery B1 and the second battery B2, and continue the discharge of the third battery B3 and the fourth battery B4.

[0064] In the Example of FIG. 5, the third battery B3 and the fourth battery B4 may continue to be discharged. The SOC of the third battery B3 and the fourth battery B4 may reach 10 %, which is the lower limit value of the second usable SOC band U2.

[0065] Then, the control unit 120 may control the charge and discharge of the first battery B1 and the second battery B2 within the first usable SOC band U1, and the charge and discharge of the third battery B3 and the fourth battery B4 within the second usable SOC band U2.

[0066] When the discharge of the plurality of batteries

B is requested despite that the SOC's of the plurality of batteries B have reached the lower limit values of their corresponding usable SOC bands, the control unit 120 may rank priorities among the plurality of usable SOC bands in a decreasing order of a band value. Then, the control unit 120 may discharge the batteries in a decreasing order of the priorities.

[0067] Specifically, the control unit 120 may discharge the plurality of batteries B while terminating the discharge of the target batteries of which SOC's reach the lower limit values of the usable SOC bands corresponding to the target batteries. Even when the discharge of all of the plurality of batteries B is terminated, the discharge request may be made continuously. In this case, the control unit 120 may set the priorities among the usable SOC bands based on band values of the plurality of usable SOC bands.

[0068] Here, the band value refers to a value included in a corresponding usable SOC band, and may be, for example, the upper limit value, the lower limit value, a mean value, or a median value of the corresponding usable SOC band. Since the plurality of usable SOC bands do not overlap with each other, the band values of the plurality of usable SOC bands may not also overlap with each other.

[0069] For example, in the Example of FIG. 5, the SOC's of all of the first battery B 1, the second battery B2, the third battery B3, and the fourth battery B4 reach the lower limit values of their corresponding usable SOC bands. Under the normal circumstances, the discharge of all of the first battery B1, the second battery B2, the third battery B3, and the fourth battery B4 needs to be terminated. However, since the first battery B1 and the second battery B2 may be further discharged, the discharge request may be continued.

[0070] Since the band value of the first usable SOC band U1 is larger than the band value of the second usable SOC band U2, the control unit 120 may set a higher priority for the first usable SOC band U1 than that for the second usable SOC band U2. Then, the control unit 120 may further discharge the first battery B1 and the second battery B2 that correspond to the first usable SOC band U1.

[0071] For example, in the Example of FIG. 6, the SOC's of the first battery B1 and the second battery B2 may reach the lower limit value of the second usable SOC band U2. Then, the control unit 120 may terminate the discharge of the first battery B1, the second battery B2, the third battery B3, and the fourth battery B4.

[0072] Thereafter, during the charge process in the Example of FIG. 7, the first battery B1 and the second battery B2 may be charged until their SOC's reach the upper limit value of the first usable SOC band U1, and the third battery B3 and the fourth battery B4 may be charged until their SOC's reach the upper limit value of the second usable SOC band U2. Then, the control unit 120 may control the charge and discharge of the first battery B1 and the second battery B2 within the first usable SOC

band U1, and the charge and discharge of the third battery B3 and the fourth battery B4 within the second usable SOC band U2.

[0073] The battery management apparatus 100 according to an embodiment of the present disclosure may extend the life expectancy of a battery by controlling the charge and discharge of the battery within its corresponding usable SOC band. When the additional discharge of a battery is necessary, the battery management apparatus 100 may further discharge the battery.

[0074] FIGS. 8 to 12 are diagrams illustrating Example 2 according to the present disclosure.

[0075] Hereinafter, Example 2 will be described, assuming that the SOC range of above 90 % and 100 % or lower is set as a first non-usable SOC band N1, the SOC range of 70 % to 90 % is set as a first usable SOC band U1, the SOC range of above 60 % and below 70 % is set as a second non-usable SOC band N2, the SOC range of 40 % to 60 % is set as a second usable SOC band U2, the SOC range of above 30 % and below 40 % is set as a third non-usable SOC band N3, the SOC range of 10 % to 30 % is set as a third usable SOC band U3, and the SOC range of 0 % or higher and below 10 % is set as a fourth non-usable SOC band N4. Further, it is assumed that a fifth battery B5 and a sixth battery B6 are set to correspond to the first usable SOC band U1, a seventh battery B7 and an eighth battery B8 are set to correspond to the second usable SOC band U2, and a ninth battery B9 and a tenth battery B10 are set to correspond to the third usable SOC band U3.

[0076] The usable SOC bands and the non-usable SOC bands illustrated in FIGS. 7 and 8 are bands arbitrarily selected for the convenience of description. Thus, buffer bands set appropriately through experiments (SOC bands for preventing the full charge and the full discharge) and the graphite staging band may be set as non-usable SOC bands. Then, usable SOC bands may be set according to the set non-usable SOC bands. For example, the usable SOC bands and the non-usable SOC bands are not limited to those in the Examples of FIGS. 7 and 8.

[0077] In the Example of FIG. 8, the SOC's of the fifth battery B5 and the sixth battery B6 are 90 %, which may be the same as the upper limit value of the first usable SOC band U1. The SOC's of the seventh battery B7 and the eighth battery B8 are 60 %, which may be the same as the upper limit value of the second usable SOC band U2. The SOC's of the ninth battery B9 and the tenth battery B10 are 30 %, which may be the same as the upper limit value of the third usable SOC band U3.

[0078] In the Example of FIG. 9, the fifth battery B5, the sixth battery B6, the seventh battery B7, the eighth battery B8, the ninth battery B9, and the tenth battery B10 may be discharged. The SOC's of the fifth battery B5 and the sixth battery B6 are 70 %, which may be the same as the lower limit value of the first usable SOC band U1. The SOC's of the seventh battery B7 and the eighth battery B8 are 40 %, which may be the same as the lower limit value

of the second usable SOC band U2. The SOC of the ninth battery B9 and the tenth battery B10 are 10 %, which may be the same as the lower limit value of the third usable SOC band U3.

[0079] Then, when the discharge request is continued, the control unit 120 may set priorities of the usable SOC bands in the order of the first usable SOC band U1, the second usable SOC band U2, and the third usable SOC band U3, which rank in an order from the highest band value to the lowest band value.

[0080] For example, in the Example of FIG. 10, the fifth battery B5 and the sixth battery B6 are further discharged, and the SOC of the fifth battery B5 and the sixth battery B6 may reach the lower limit value of the second usable SOC band U2. Here, when the fifth battery B5 and the sixth battery B6 are further discharged, the fifth battery B5 and the sixth battery B6 may be discharged even in the third non-usable SOC band N3. In this case, the plurality of batteries B may degrade in disequilibrium.

[0081] In order to help the plurality of batteries B degrade in equilibrium, the control unit 120 may be configured such that, when the SOC of batteries being discharged reach the lower limit value of the usable SOC band with the subsequent priority, batteries corresponding to the usable SOC band with the subsequent priority are discharged.

[0082] For example, in the Example of FIG. 10, the SOC of the fifth battery B5, the sixth battery B6, the seventh battery B7, and the eighth battery B8 are 40 %, which may be the same as the lower limit value of the second usable SOC band U2. When the discharge request continues, the control unit 120 may discharge the seventh battery B7 and the eighth battery B8 that correspond to the second usable SOC band U2 with the subsequent priority.

[0083] For example, in the Example of FIG. 11, the seventh battery B7 and the eighth battery B8 may be discharged. For example, the seventh battery B7 and the eighth battery B8 may be 10 % SOC, which may be the same as the lower limit value of the third usable SOC band U3. Accordingly, the SOC of the seventh battery B7, the eighth battery B8, the ninth battery B9, and the tenth battery B10 may be the same as the lower limit value of the third usable SOC band U3.

[0084] It is assumed that the discharge request is continued even thereafter. In this case, since the ninth battery B9 and the tenth battery B10, which correspond to the third usable SOC band U3 with the last priority, may no longer be discharged, the fifth battery B5 and the sixth battery B6, which correspond to the first usable SOC band U1, may be discharged further again.

[0085] For example, in the Example of FIG. 12, the fifth battery B5 and the sixth battery B6 may be discharged. The fifth battery B5 and the sixth battery B6 may be 10 % SOC, which may be the same as the lower limit value of the third usable SOC band U3. That is, the SOC of all of the fifth battery B5, the sixth battery B6, the seventh

battery B7, the eighth battery B8, the ninth battery B9, and the tenth battery B10 may be the same at 10 % SOC.

[0086] During the charge process thereafter, the fifth battery B5 and the sixth battery B6 may be charged until their SOC reach the upper limit value of the first usable SOC band U1, the seventh battery B7 and the eighth battery B8 may be charged until their SOC reach the upper limit value of the second usable SOC band U2, and the ninth battery B9 and the tenth battery B10 may be charged until their SOC reach the upper limit value of the third usable SOC band U3. Then, the control unit 120 may control the charge and discharge of the fifth battery B5 and the sixth battery B6 within the first usable SOC band U1. The control unit 120 may control the charge and discharge of the seventh battery B7 and the eighth battery B8 within the second usable SOC band U2. The control unit 120 may control the charge and discharge of the ninth battery B9 and the tenth battery B10 within the third usable SOC band U3.

[0087] The battery management apparatus 100 according to an embodiment of the present disclosure may control the charge and discharge of the plurality of batteries B, such that the plurality of batteries B degrade in equilibrium even when the discharge request is made continuously.

[0088] The control unit 120 may set equal intervals for the plurality of usable SOC bands.

[0089] If the intervals of the usable SOC bands are different from each other, the degradation of the batteries may become unbalanced according to the corresponding usable SOC bands.

[0090] For example, it may be assumed that the interval of an N-1-th usable SOC band is 30 % SOC, and the interval of an N-th usable SOC band is 40 % SOC. Here, the interval of the SOC band refers to an SOC range included in a usable SOC band, and may be calculated through the formula of a "lower limit value-an upper limit value."

[0091] In this case, batteries corresponding to the N-1-th usable SOC band may be charged and discharged within the interval of 30 % SOC, while batteries corresponding to the N-th usable SOC band may be charged and discharged within the interval of 40 % SOC. Since the intervals of the charge and discharge SOC bands differ among the plurality of batteries B, the batteries corresponding to the N-th usable SOC band may degrade more quickly than the batteries corresponding to the N-1-th usable SOC band.

[0092] Therefore, the battery management apparatus 100 sets equal intervals for the plurality of usable SOC bands, to prevent the unbalance in degradation of the plurality of batteries B.

[0093] The control unit 120 may set a different number of batteries to correspond to each of the plurality of usable SOC bands.

[0094] Preferably, the control unit 120 may be configured to set the number of batteries such that the larger the band value of a usable SOC band, the greater the number

of batteries corresponding to the usable SOC band.

[0095] For example, in the Example of FIG. 8, when the number of the plurality of batteries B is increased, the number of batteries corresponding to each usable SOC band may be decreased in the order of the first usable SOC band U1, the second usable SOC band U2, and the third usable SOC band U3. For example, the number of batteries corresponding to the first usable SOC band U1 may be the largest, and the number of batteries corresponding to the third usable SOC band U3 may be the smallest.

[0096] The plurality of batteries B may be fully charged (100 % SOC) at the initial time, and discharged in accordance with their corresponding usable SOC bands. In this case, the batteries corresponding to the usable SOC band with the high band value pass through more non-usable SOC bands than the batteries corresponding to the usable SOC band with the high band value do. For example, in the Example of FIG. 8, the fifth battery B5 and the sixth battery B6 are discharged passing through only the first non-usable SOC band N1, whereas the seventh battery B7 and the eighth battery B8 are discharged passing through the first non-usable SOC band N1 and the second non-usable SOC band N2. Further, the ninth battery B9 and the tenth battery B10 are discharged passing through all of the first non-usable SOC band N1, the second non-usable SOC band N2, and the third non-usable SOC band N3. In this discharge stage, the ninth battery B9 and the tenth battery B10, which correspond to the third usable SOC band U3 with the low band value, may degrade more quickly than the other batteries. Thus, when more batteries are set to correspond to the usable SOC band with the high band value than the batteries corresponding to the usable SOC band with the low band value, the overall degradation degree of the plurality of batteries may decline.

[0097] Taking this point into consideration, the battery management apparatus 100 may set the number of batteries corresponding to the usable SOC bands to differ according to the band values of the usable SOC bands.

[0098] The battery management apparatus 100 according to the present disclosure may be applied to a battery management system (BMS). For example, a BMS according to the present disclosure may include the battery management apparatus 100 described above. In this configuration, at least a portion of the components of the battery management apparatus 100 may be implemented by enhancing or adding functions of components of a well-known BMS. For example, the measurement unit 110, the control unit 120, and the storage unit 130 of the battery management apparatus 100 may be implemented as components of a BMS.

[0099] Further, the battery management apparatus 100 according to the present disclosure may be provided in a battery pack 1. For example, the battery pack 1 according to the present disclosure may include the battery management apparatus 100 described above and one or more battery cells. The battery pack 1 may

further include electric components (e.g., relays and fuses), a case and so on.

[0100] In the embodiment of FIG. 2, the positive terminal of each battery B may be connected to the positive terminal P+ of the battery pack 1, and the negative terminal of the battery B may be connected to the negative terminal P- of the battery pack 1.

[0101] An external device may be connected to the positive terminal P+ and the negative terminal P- of the battery pack 1. Thus, the positive terminal of the battery B, the positive terminal P+ of the battery pack 1, the external device, the negative terminal P- of the battery pack 1, and the negative terminal of the battery B may be electrically connected to each other.

[0102] For example, the external device may be a charging or discharging device, or a load such as a motor of an electric vehicle, which is powered from the plurality of batteries B.

[0103] FIG. 13 is a flow diagram schematically illustrating a battery management method according to another embodiment of the present disclosure.

[0104] Each step of the battery management method may be performed by the battery management apparatus 100. Hereinafter, for the convenience of description, descriptions overlapping with the descriptions above will be omitted or summarized briefly.

[0105] Referring to FIG. 13, the battery management method may include a voltage measuring step (S100), an SOC estimating step (S200), and a charge/discharge controlling step (S300).

[0106] The voltage measuring step S100 is a step of measuring voltages of the plurality of batteries B connected in series to each other, and may be performed by the measurement unit 110.

[0107] Specifically, the measurement unit 110 may measure the voltage of each of the plurality of batteries B. Then, the measurement unit 110 may transmit information of the measured voltage to the control unit 120.

[0108] The SOC estimating step S200 is a step of estimating the SOC of the plurality of batteries B based on the voltages, and may be performed by the control unit 120.

[0109] Specifically, the control unit 120 may estimate the SOC of each of the plurality of batteries B by using the table representing the association relationship between voltages and SOC.

[0110] The charge and discharge controlling step S300 is a step of controlling the charge and discharge of the plurality of batteries B, such that the SOC of the plurality of batteries B fall within the plurality of usable SOC bands preset to correspond to the plurality of batteries B, and may be performed by the control unit 120.

[0111] Specifically, each of the plurality of batteries B may be preset to correspond to one of the plurality of usable SOC bands. Then, the control unit 120 may control the charge and discharge of the plurality of batteries B such that the SOC of the plurality of batteries B fall in the corresponding usable SOC bands.

[0112] In the embodiment of FIG. 2, the control unit 120 may set a target battery of which SOC reaches the lower limit value of the corresponding usable SOC band, and control the operation state of the bypass switch S connected in parallel to the target battery to the ON state. In this case, the target battery may be excluded from the batteries subjected to the charge and discharge, so that the charge and discharge of the target battery may be stopped.

[0113] The embodiments of the present disclosure described above may not be limited to an apparatus and a method, but may also be implemented by programs that implement the functions corresponding to the components of the embodiments of the present disclosure, or a recording medium that stores the programs. The programs or recording medium may easily be implemented by one skilled in the field of the present disclosure from the descriptions of the embodiments above.

[0114] While the present disclosure has been described using the embodiments and the drawings, the present disclosure is not limited thereto. Various modifications and changes may be made by one of ordinary skill in the art to which the present disclosure belongs, within the scope equivalent to the technical idea of the present disclosure and the claims set forth below.

[0115] Further, since various substitutions, modifications, and changes may be made to the present disclosure by one of ordinary skilled in the art within the scope that does not depart from the technical idea of the present disclosure, the present disclosure is not limited by the foregoing embodiments and the drawings attached herewith, but all or some of the embodiments may be selectively combined to implement various modifications.

List of Reference Numerals

[0116]

- 1: battery pack
- 100: battery management apparatus
- 110: measurement unit
- 120: control unit
- 130: storage unit

Claims

1. A battery management apparatus comprising:

- a voltage meter configured to measure voltages of a plurality of batteries connected in series to each other; and
- a controller configured to estimate State of Charges (SOCs) of the plurality of batteries based on the voltages, and control charge and discharge of the plurality of batteries to make the SOCs of the plurality of batteries fall within a plurality of usable SOC bands preset to corre-

spond to the plurality of batteries.

2. The battery management apparatus according to claim 1, wherein the plurality of usable SOC bands are divided based on preset non-usable SOC bands, and set to not overlap with each other.
3. The battery management apparatus according to claim 1, wherein the controller controls an operation state of a bypass switch disposed in a bypass path connected in parallel to each of the plurality of batteries, to control the charge and discharge of the plurality of batteries.
4. The battery management apparatus according to claim 3, wherein during the charge of the plurality of batteries, the controller selects a target battery with an SOC reaching an upper limit value of a usable SOC band corresponding to the target battery, and controls the operation state of the bypass switch connected in parallel to the target battery to an ON state.
5. The battery management apparatus according to claim 3, wherein during the discharge of the plurality of batteries, the controller selects a target battery with an SOC reaching a lower limit value of a usable SOC band corresponding to the target battery, and controls the operation state of the bypass switch connected in parallel to the target battery to an ON state.
6. The battery management apparatus according to claim 1, wherein when the plurality of batteries are requested to be discharged despite that the SOCs of the plurality of batteries have reached lower limit values of the usable SOC bands corresponding to the plurality of batteries, the controller sets priorities among the plurality of usable SOC bands in a decreasing order of band values of the plurality of usable SOC bands, and discharges the plurality of batteries from batteries corresponding to a usable SOC band with a highest priority to batteries corresponding to a usable SOC band with a lowest priority.
7. The battery management apparatus according to claim 6, wherein when the SOCs of discharged batteries reach a lower limit value of a usable SOC band with a subsequent priority, the controller discharges batteries corresponding to the usable SOC band with the subsequent priority.
8. The battery management apparatus according to claim 1, wherein the controller sets intervals of the plurality of usable SOC bands to be equal to each other.
9. The battery management apparatus according to

claim 1, wherein the controller sets a different number of batteries to correspond to each of the plurality of usable SOC bands.

10. The battery management apparatus according to claim 9, wherein the controller sets the different number of batteries such that the larger a band value of a usable SOC band, the greater the number of batteries corresponding to the SOC band.

11. A battery pack comprising the battery management apparatus according to any one of claims 1 to 10.

12. A battery management method comprising:

measuring voltages of a plurality of batteries connected in series to each other;
estimating State of Charges (SOCs) of the plurality of batteries based on the voltages; and
controlling charge and discharge of the plurality of batteries to make the SOCs of the plurality of batteries fall within a plurality of usable SOC bands preset to correspond to the plurality of batteries.

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FIG. 1

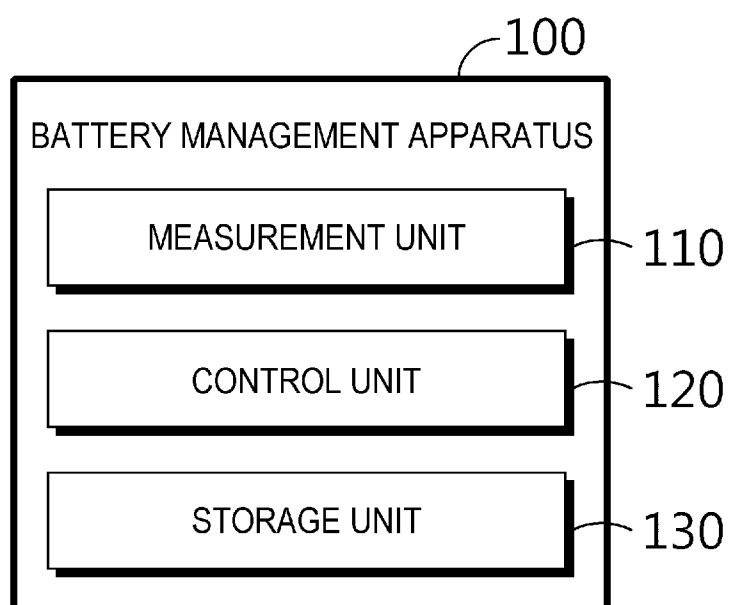


FIG. 2

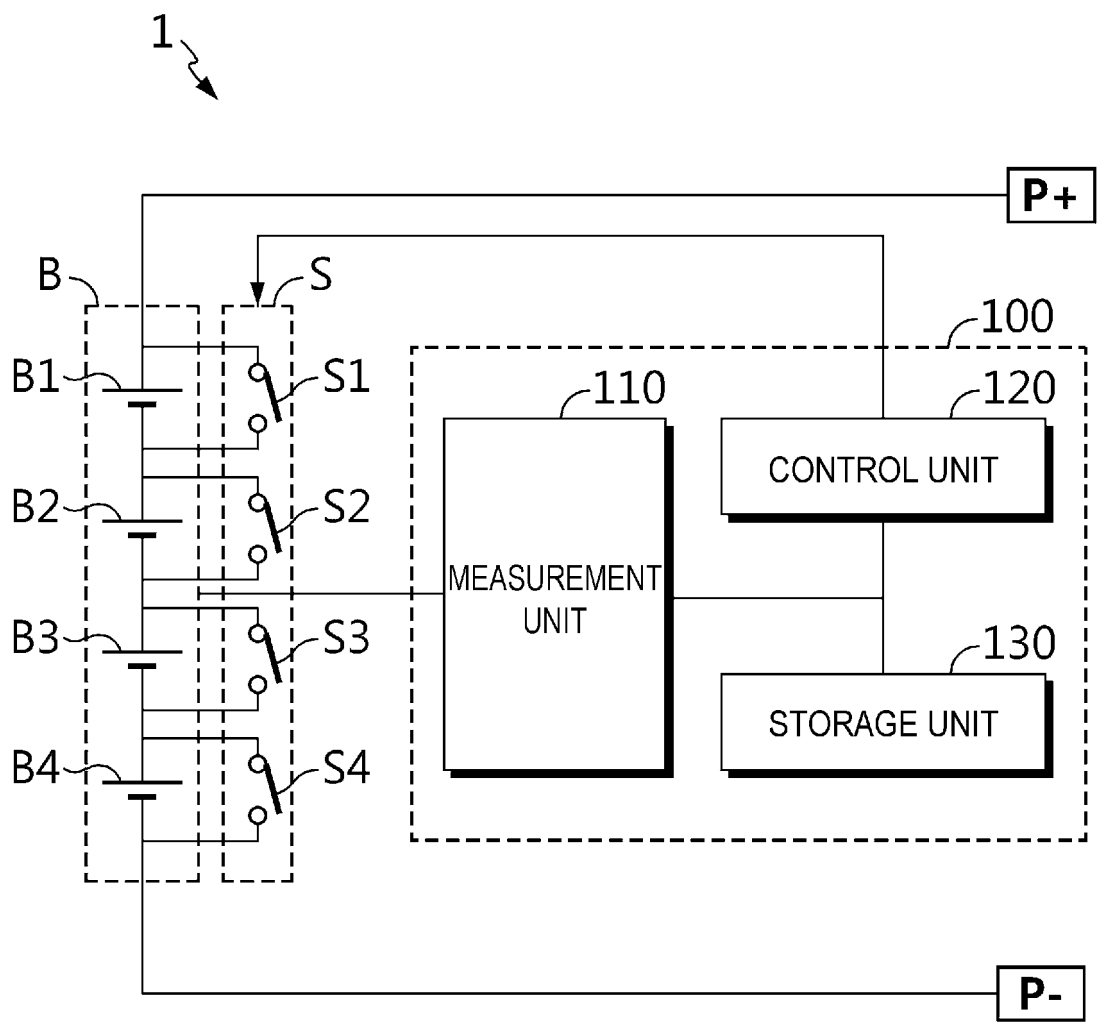


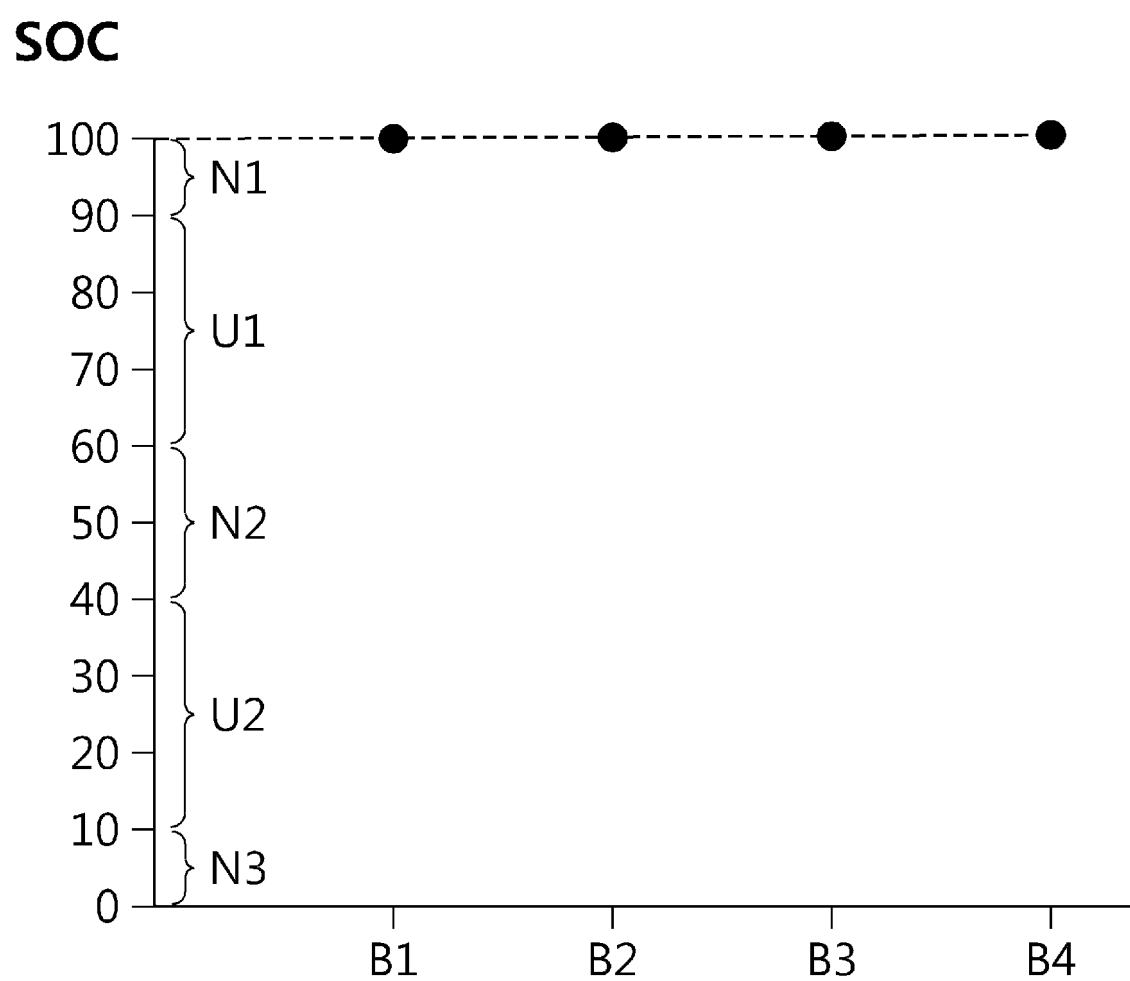
FIG. 3

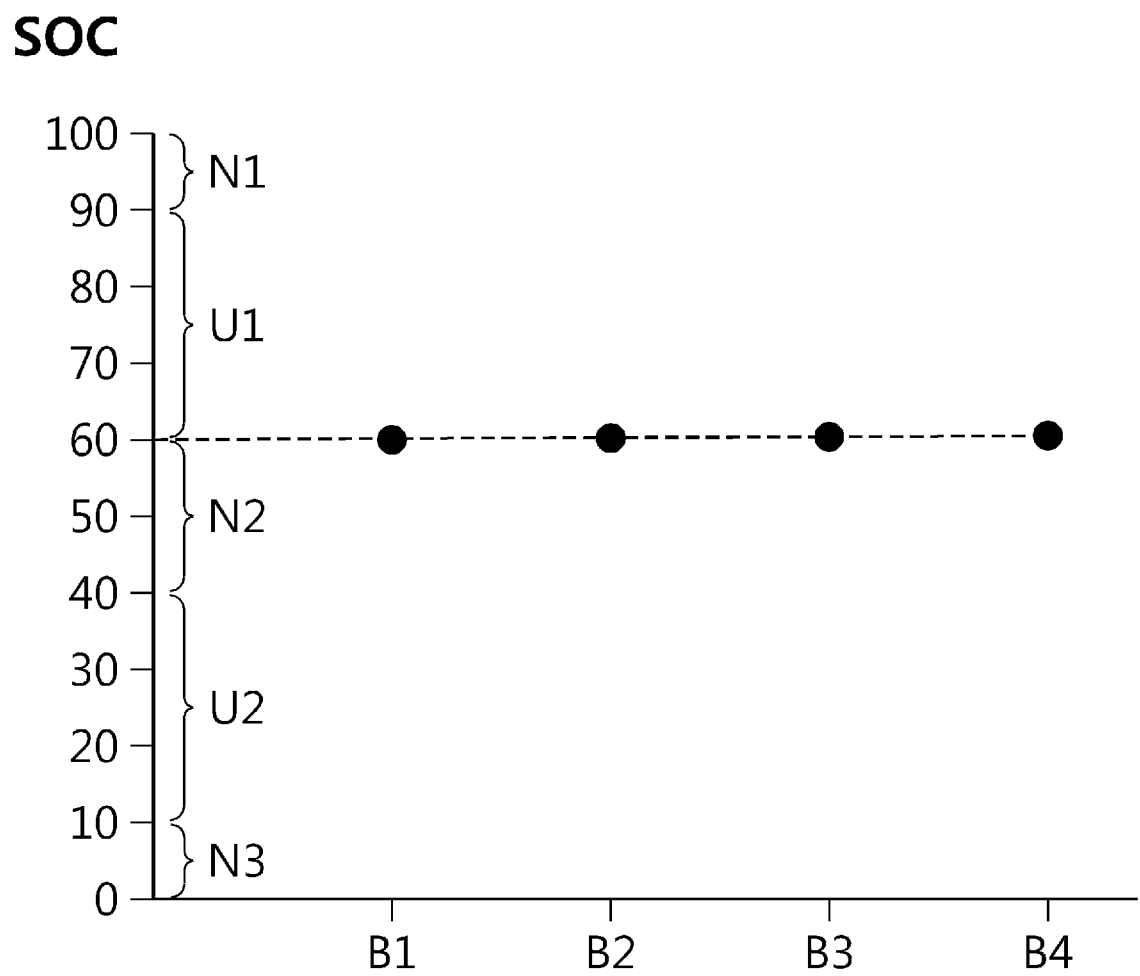
FIG. 4

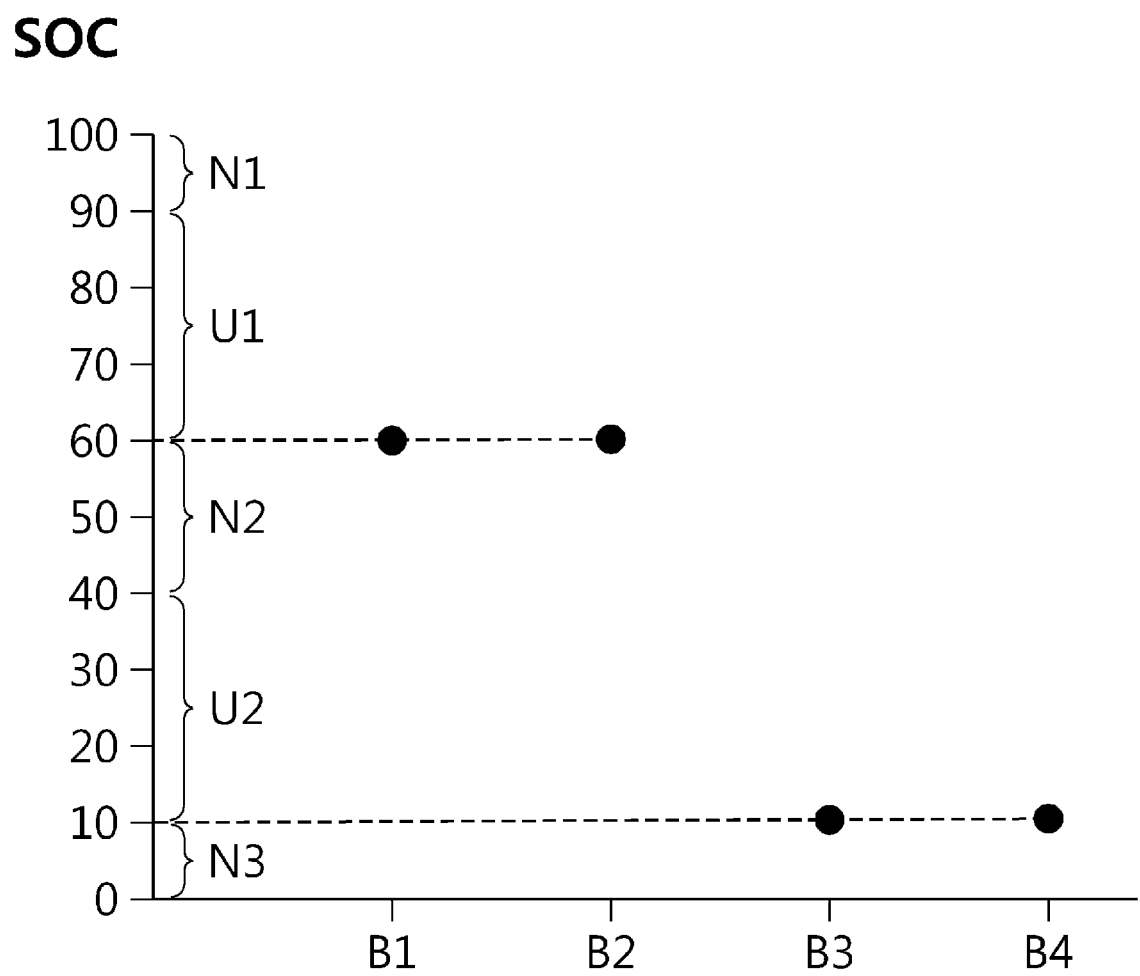
FIG. 5

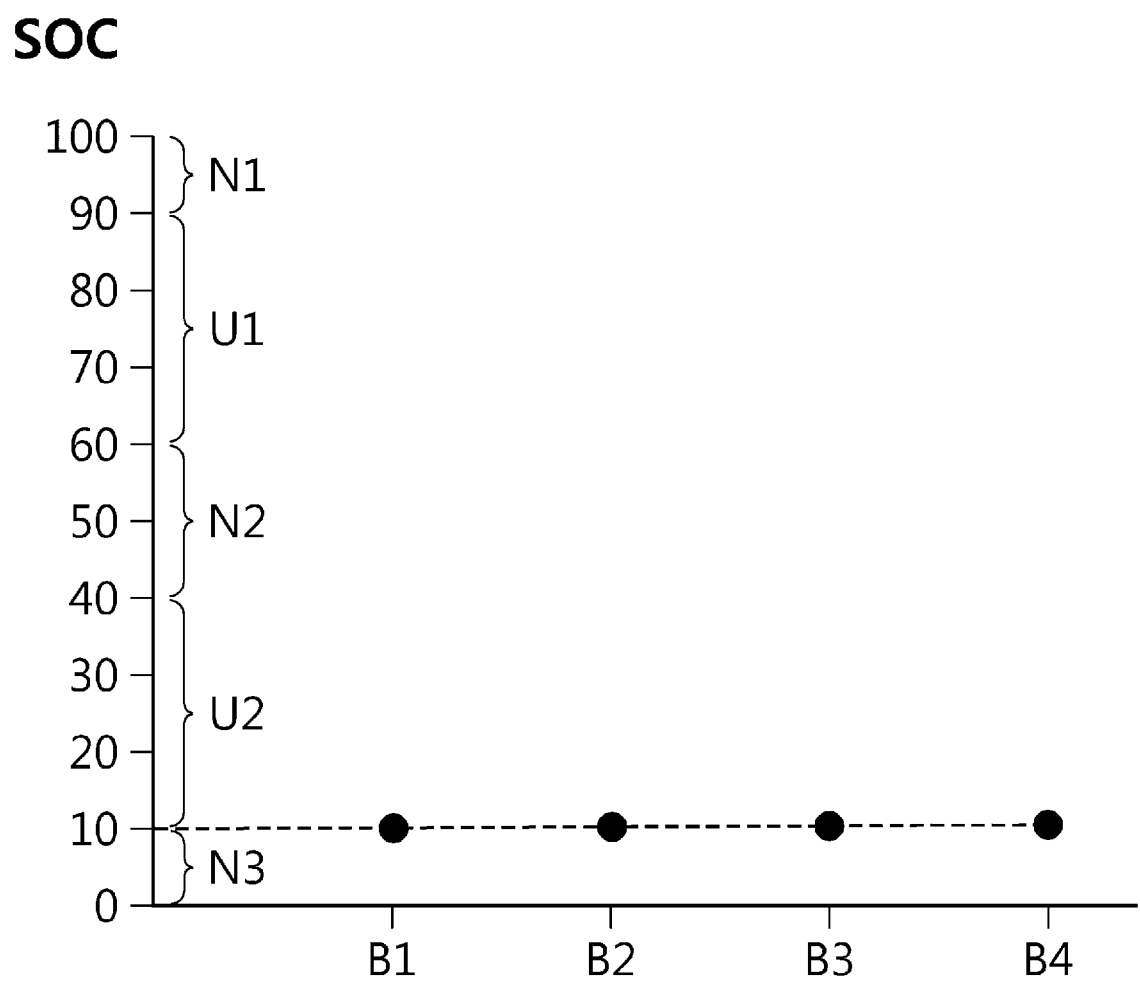
FIG. 6

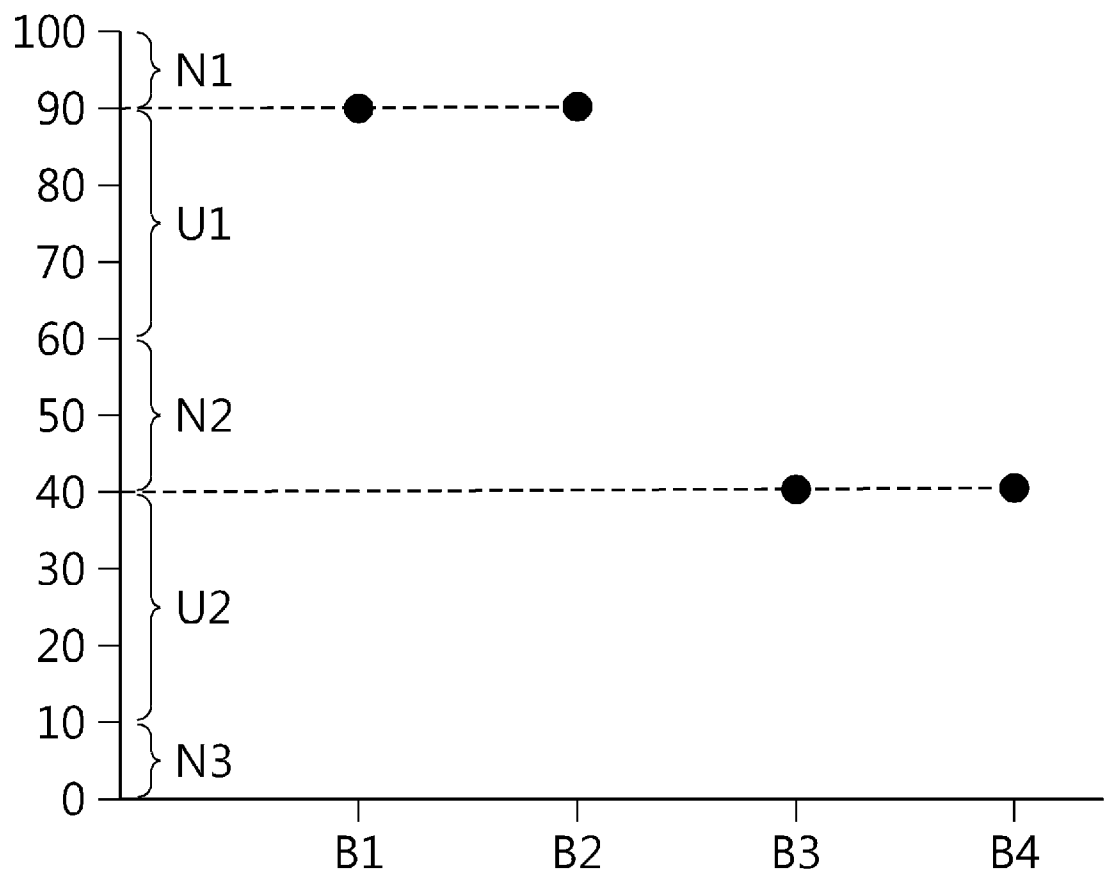
FIG. 7**SOC**

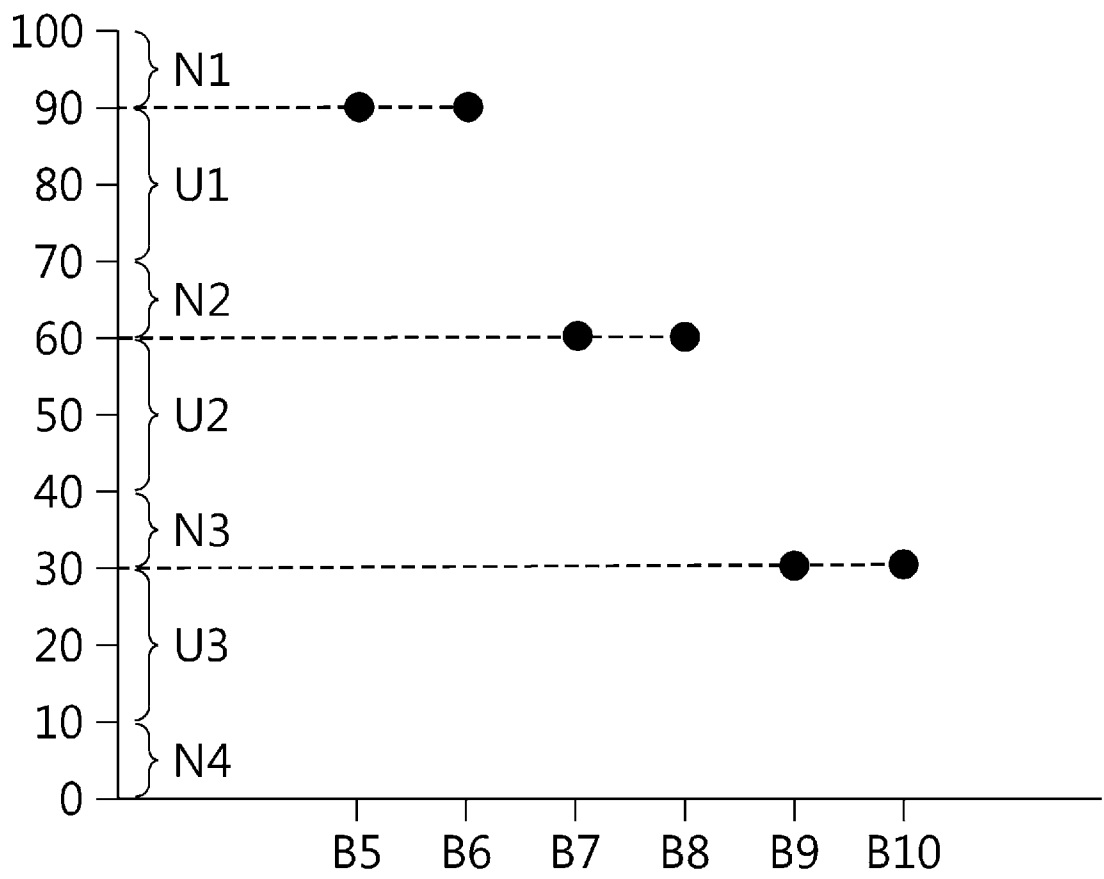
FIG. 8**SOC**

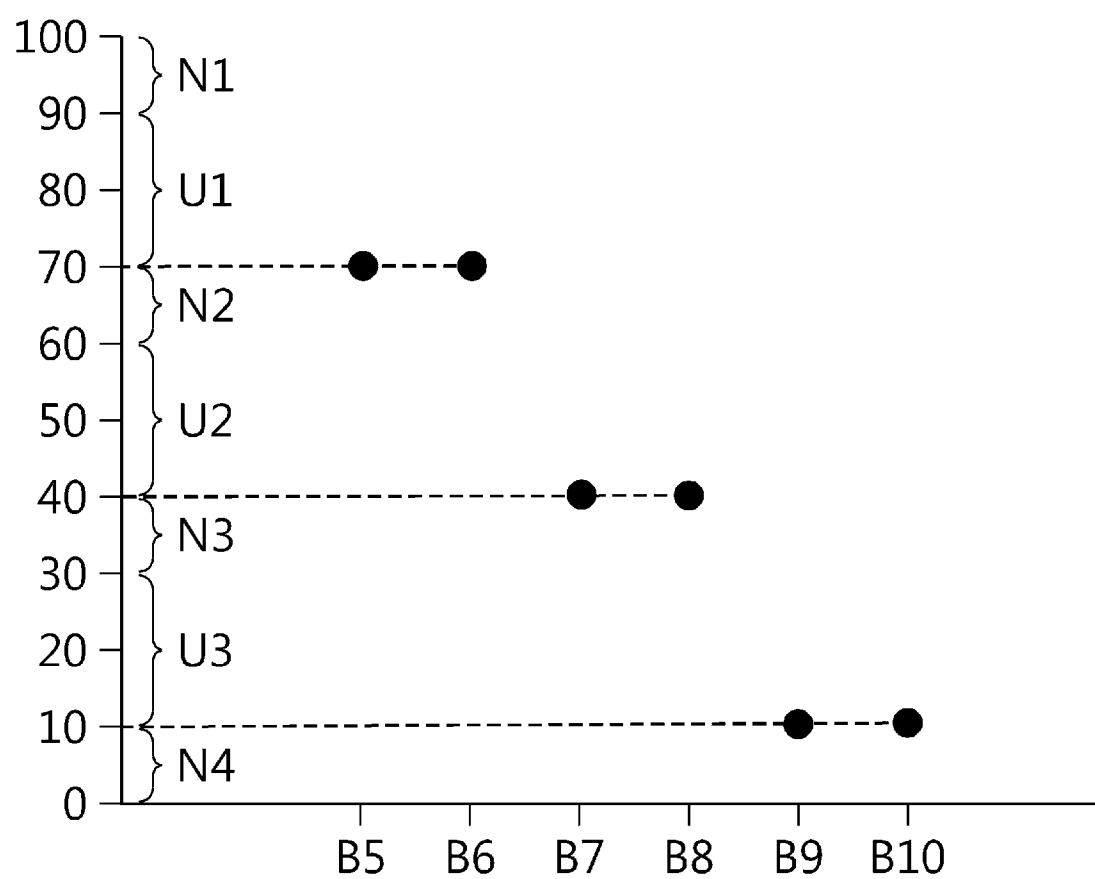
FIG. 9**SOC**

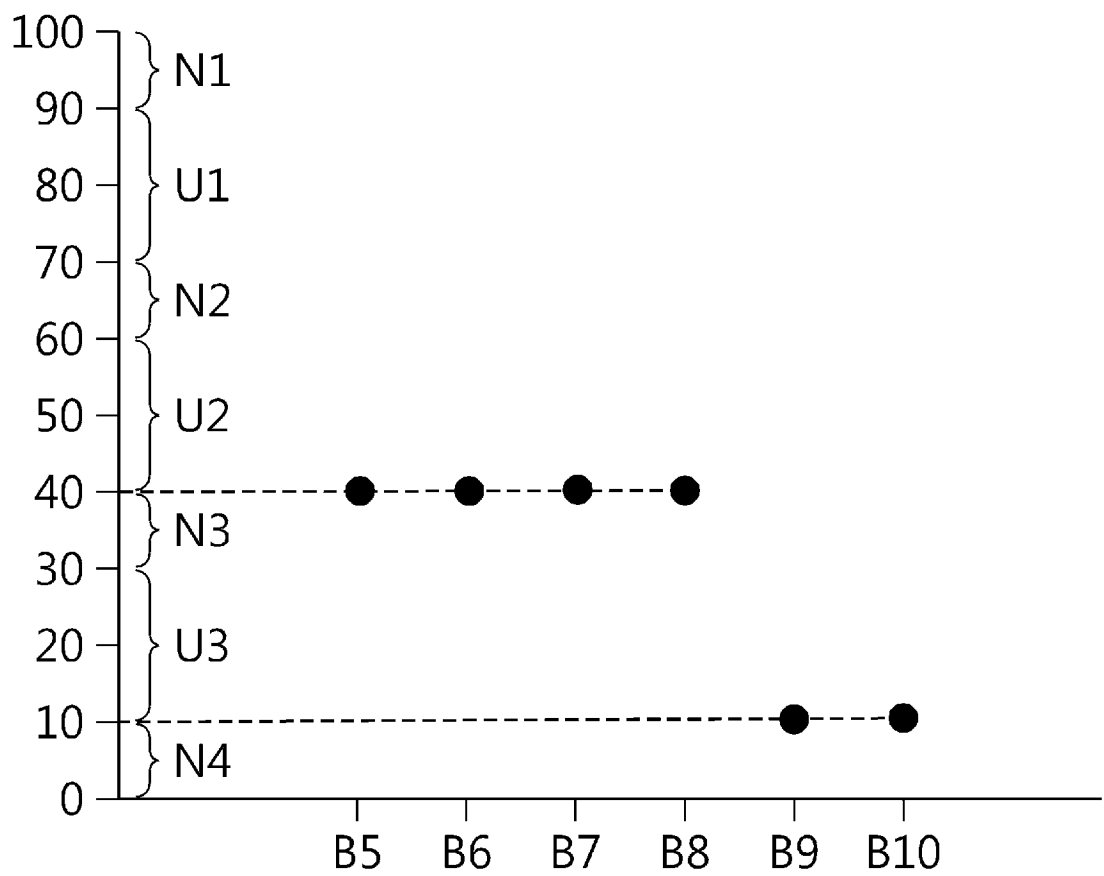
FIG. 10**SOC**

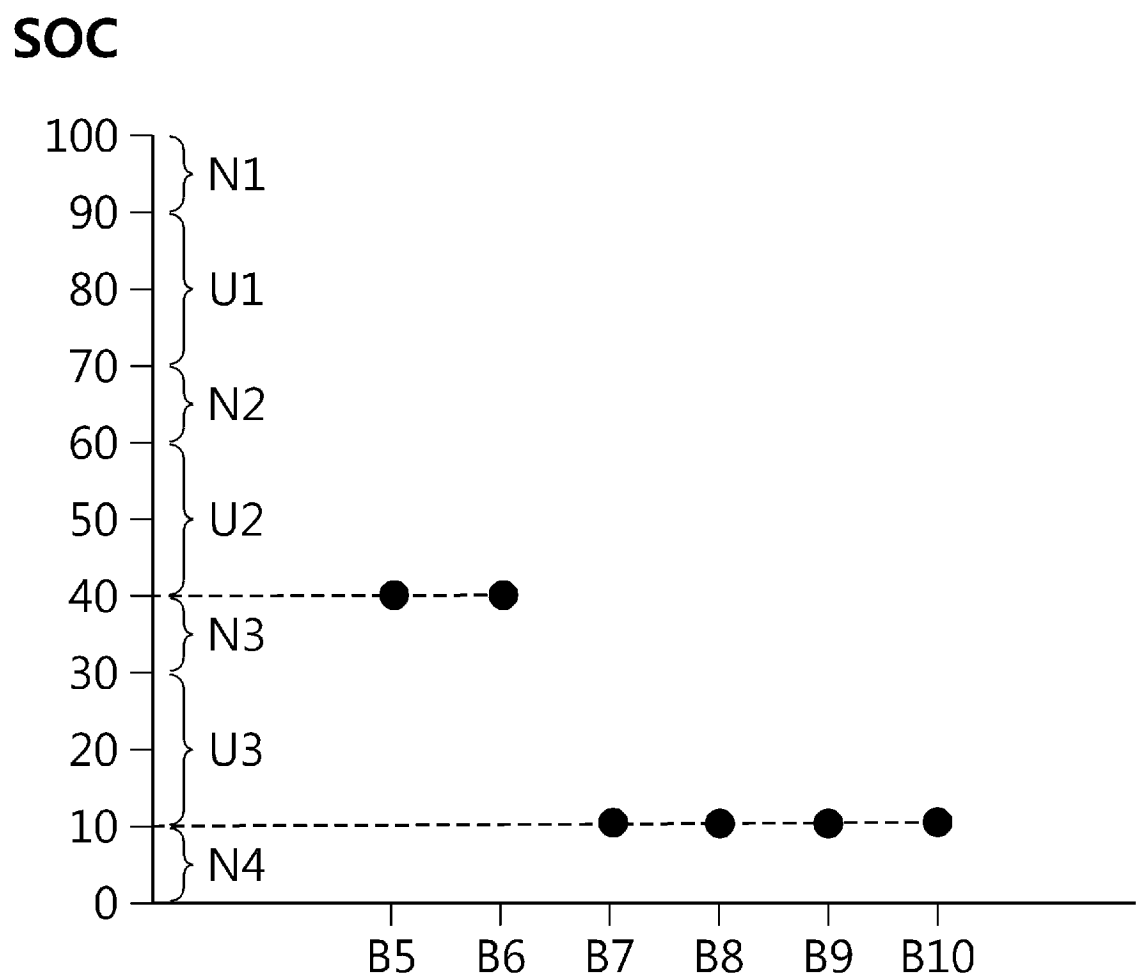
FIG. 11

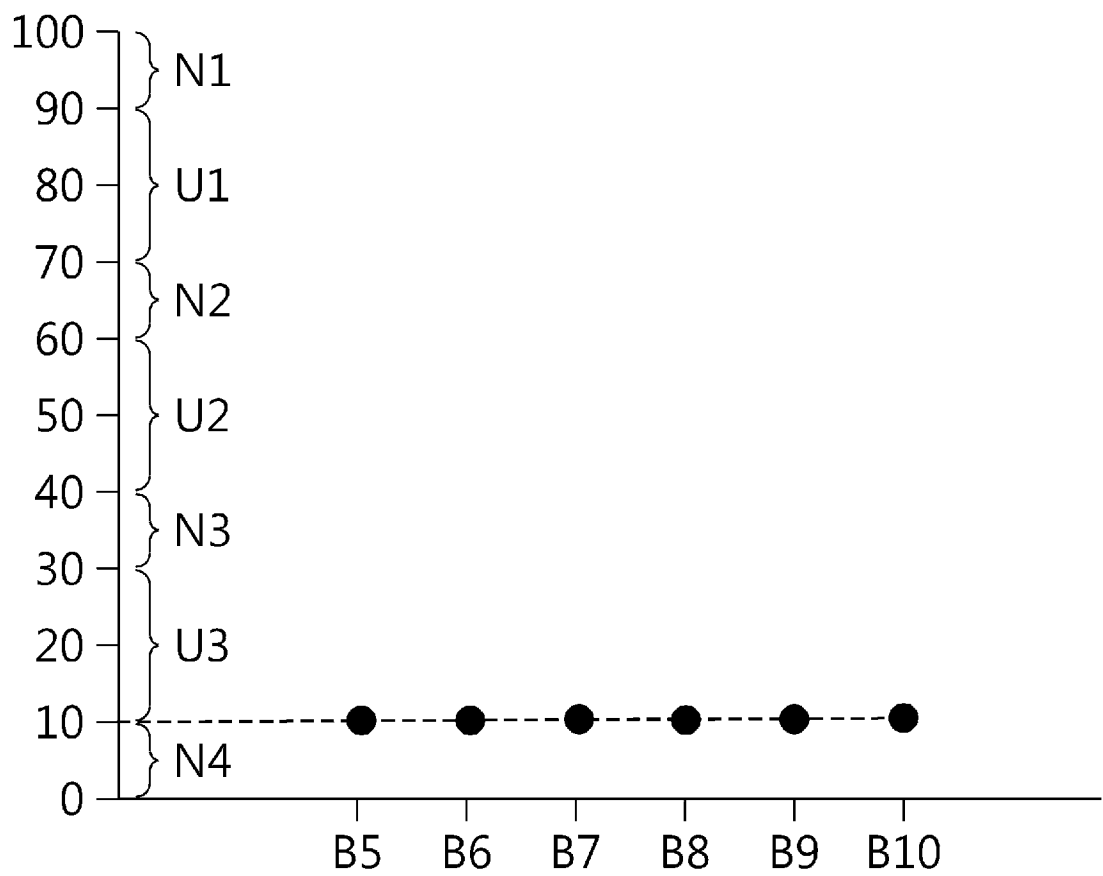
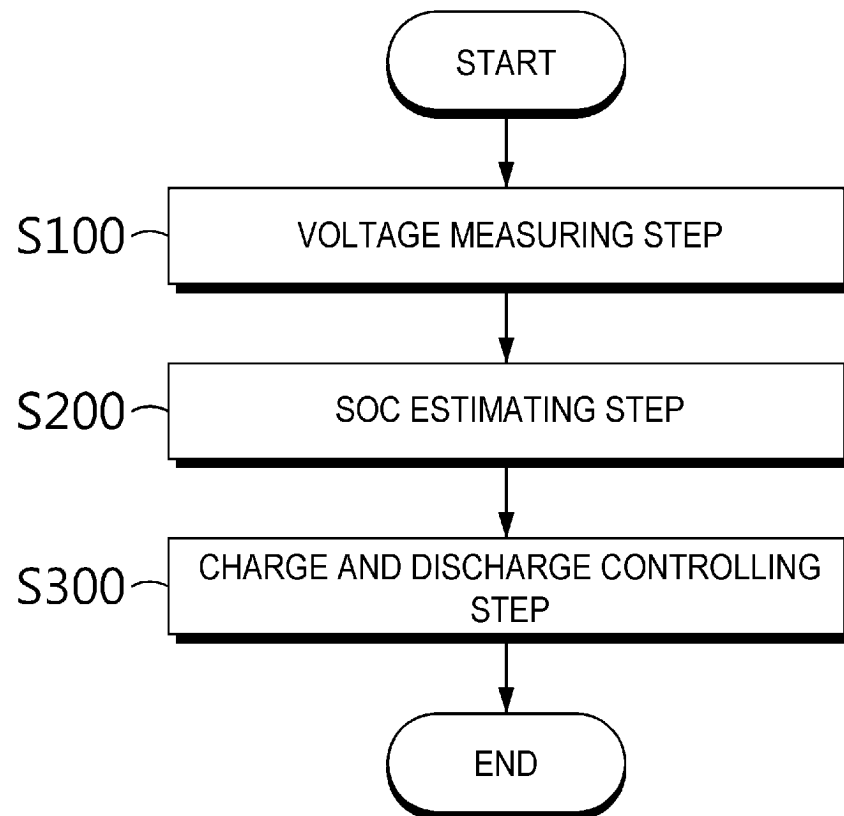
FIG. 12**SOC**

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/001478

A. CLASSIFICATION OF SUBJECT MATTER

H02J 7/00(2006.01)i; G01R 31/382(2019.01)i; G01R 31/392(2019.01)i; G01R 31/385(2019.01)i; G01R 31/396(2019.01)i;
H01M 10/44(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02J 7/00(2006.01); B60L 58/22(2019.01); F02D 17/00(2006.01); F02D 29/02(2006.01); G01R 31/382(2019.01);
H01M 10/44(2006.01); H01M 10/48(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models: IPC as above

Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & keywords: 배터리(battery), 우선순위(priority), 밸런싱(balancing), 스위치(switch), 임계값(threshold)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2020-0086960 A (LG CHEM, LTD.) 20 July 2020 (2020-07-20) See paragraphs [0038]-[0049], [0057]-[0062] and [0128]-[0140]; and figures 1-2 and 5-7.	1-12
Y	KR 10-2022-0117040 A (LG ENERGY SOLUTION, LTD.) 23 August 2022 (2022-08-23) See paragraphs [0058]-[0068]; and figure 3.	1-12
Y	KR 10-2330260 B1 (KIM, Doe Hyoung) 24 November 2021 (2021-11-24) See paragraphs [0040]-[0042] and [0054]-[0071]; and figure 2.	3-7
Y	JP 2018-127977 A (DENSO CORP.) 16 August 2018 (2018-08-16) See paragraphs [0038]-[0042].	9-10
A	JP 2020-053240 A (HONDA MOTOR CO., LTD.) 02 April 2020 (2020-04-02) See entire document.	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

20 May 2024

Date of mailing of the international search report

20 May 2024

Name and mailing address of the ISA/KR

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Authorized officer

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Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2024/001478

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